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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In the Continuation Application of the U.S.
Patent Application of
Chien-Hua Chen

Serial No.: Unassigned 10/666,609

Continuation Application Filed: Herewith

A continuation of:
Serial No. 10/120,944
Filed: **April 10, 2002**

For: A Pressure Sensor and Method of Making the Same

Group Art Unit: Unassigned

Examiner: Unassigned

PRELIMINARY AMENDMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Prior to examination of the above-identified patent application, please amend the application as follows.

IN THE SPECIFICATION

Please replace paragraph 0001 and its title as follows:

~~FIELD OF THE INVENTION~~

~~[0001] The present invention relates to the field of pressure sensors and the field of fabricating pressure sensors. The present invention also relates to the field of integrating pressure sensors with other devices and systems.~~

RELATED APPLICATIONS

[0001] The present application is a continuation of, and claims priority from, U.S. Patent Application No. 10/120,944, filed April 10, 2002, which application is incorporated herein by reference in its entirety.

Please amend the title of paragraph 0002 as follows:

BACKGROUND ~~OF THE INVENTION~~

Please amend paragraph 0002 as follows:

[0002] Conventional pressure sensors are used in a wide variety of applications to monitor or control pressure in devices or systems where maintaining a particular pressure is important. However, conventional pressure sensors are relatively large.

Please amend the title of paragraph 0004 as follows:

SUMMARY ~~OF THE INVENTION~~

Please amend the title of paragraph 0014 as follows:

DETAILED DESCRIPTION ~~OF THE INVENTION~~

Please amend paragraph 0022 as follows:

[0022] A second silicon membrane (102), which is preferably thicker and less flexible that the thin membrane (101), is formed adjacent to the thin membrane (101) outside the reference cavity (103). The two membranes (101, 102) and the walls defining the reference cavity (103) are supported between [[and]] an upper substrate (104) and a lower substrate (105). A bonding layer (106) secures the membranes (101, 102) between the upper (104) and lower (105) substrates.

Please amend paragraph 0035 as follows:

[0035] As shown in Fig. 3[[.]], a MEMS (130), or a number of MEMS (130) formed on a single die (131), may ~~required~~ require an input, such as air, a gas or liquid, that is under pressure. Consequently, Fig. 3 illustrates a MEMS (130) that uses five different pressurized inputs (132a-132e).

Please amend paragraph 0054 as follows:

This is just one example of a possible process that can be used to fabricate a vertical pressure sensor [[of]] according to principles of the present invention. Other

processes will be apparent to those skilled the in art with the benefit of this disclosure. Such fabrication processes may or may not include integrating the pressure sensor with an ARS, MEMS or other device. The bottom line is that the vertical pressure sensor of the present invention can be integrated into many different MEMS, ARS or other designs much better than existing pressure sensors due to its small size requirements and the fact that it can be constructed in a silicon substrate from or on which many other types of devices can also be constructed.

IN THE CLAIMS:

Please amend the claims as follows:

1. (currently amended) A pressure sensor comprising:

a first membrane that flexes in response to pressure;

a reference cavity covered by said first membrane, said reference cavity containing a vacuum; and

a second membrane adjacent to said first membrane;

wherein said second membrane is not in contact with said vacuum; and ~~not within said reference cavity,~~

wherein said first and second membranes ~~forming~~ form a capacitor having a capacitance that varies in accordance with the flexing of said first membrane and said pressure.

2. (original) The pressure sensor of claim 1, wherein said first and second membranes are made of silicon.

3. (original) The pressure sensor of claim 1, further comprising:

an upper substrate; and

a lower substrate;

wherein said first and second membranes are supported between and bonded to said upper and lower substrates.

4. (original) The pressure sensor of claim 3, further comprising electrical connections patterned on one of said substrates and in electrical connection with said first and second membranes for measuring said capacitance.

5. (original) The pressure sensor of claim 1, wherein said first and second membranes are formed in a silicon substrate.

6. (original) The pressure sensor of claim 5, further comprising a polysilicon anchor on both edges of said first membrane securing said first membrane in said silicon substrate.

7. (original) The pressure sensor of claim 1, wherein said first or second membrane has a curvature.

8. (original) A pressure system comprising:

a pressure regulator for regulating pressure in a pressurized environment; and

a pressure sensor disposed in or in communication with said pressurized environment so as to output an indication of said pressure in said pressurized environment, wherein said pressure regulator is configured to operate in response to said output from said pressure sensor;

wherein said pressure sensor comprises

a first membrane that flexes in response to pressure,

a reference cavity covered by said first membrane, said reference cavity containing a vacuum, and

a second membrane adjacent to said first membrane and not in said reference cavity, said first and second membranes forming a capacitor having a capacitance that varies in accordance with the flexing of said first membrane and said pressure.

9. (original) The system of claim 8, wherein said first and second membranes are made of silicon.

10. (original) The system of claim 8, wherein said pressure sensor further comprises:

an upper substrate; and

a lower substrate;

wherein said first and second membranes are supported between and bonded to said upper and lower substrates.

11. (original) The system of claim 10, wherein said pressure sensor further comprises electrical connections patterned on one of said substrates and in electrical connection with said first and second membranes for measuring said capacitance.

12. (original) The system of claim 8, wherein said first and second silicon membranes are formed in a silicon substrate.

13. (original) The system of claim 12, wherein said pressure sensor further comprises a polysilicon anchor on both edges of said first membrane securing said first membrane in said silicon substrate.

14. (original) The system of claim 8, wherein said pressure regulator comprises a vacuum pump.

15. (original) The system of claim 8, wherein said pressure regulator comprises a compressor.

16. (original) The system of claim 8, wherein said pressure regulator comprises a getter.

17. (original) The pressure sensor of claim 8, wherein said first or second membrane has a curvature.

18. (original) A pressure sensor integrated with a microelectromechanical system (MEMS) comprising:

a silicon substrate;

a MEMS formed on or in said substrate; and

a pressure sensor formed in said substrate, said pressure sensor comprising

a first membrane that flexes in response to pressure;

a reference cavity covered by said first membrane, said reference cavity containing a vacuum; and

a second membrane adjacent to said first membrane and not in said reference cavity, said first and second membranes forming a capacitor having a capacitance that varies in accordance with the flexing of said first membrane and said pressure.

19. (original) The integrated pressure sensor and MEMS of claim 18, wherein said first and second membranes are made of silicon.

20. (original) The integrated pressure sensor and MEMS of claim 18, further comprising a polysilicon anchor on both edges of said first membrane securing said first membrane in said silicon substrate.

21. (original) The pressure sensor of claim 18, wherein said first or second membrane has a curvature.

22. (original) A pressure sensor integrated with an atomic resolution storage (ARS) device comprising:

a first substrate;

an ARS device formed partially in said first substrate; and

a pressure sensor formed in said first substrate, said pressure sensor comprising

a first membrane that flexes in response to pressure;

a reference cavity covered by said first membrane, said reference cavity containing a vacuum; and

a second membrane adjacent to said first membrane and not in said reference cavity, said first and second membranes forming a capacitor having a capacitance that varies in accordance with the flexing of said first membrane and said pressure;

wherein said pressure sensor monitors a vacuum in which said ARS device is contained.

23. (original) The integrated pressure sensor and ARS device of claim 22, wherein said first substrate is made of silicon and said first and second membranes are made of silicon.

24. (original) The integrated pressure sensor and ARS device of claim 22, further comprising:

an upper substrate; and

a lower substrate;

wherein said first substrate is bonded between said upper and lower substrates.

25. (original) The integrated pressure sensor and ARS device of claim 24, further comprising electrical connections patterned on at least one of said upper and lower substrates and in electrical connection with said first and second membranes for measuring said capacitance.

26. (original) The integrated pressure sensor and ARS device of claim 22, further comprising a polysilicon anchor on both edges of said first membrane securing said first membrane in said first substrate.

27. (original) The pressure sensor of claim 22, wherein said first or second membrane has a curvature.

28. (original) A method of fabricating a pressure sensor comprising etching a silicon substrate to form a reference cavity, a first membrane and a second membrane.

29. (original) The method sensor of claim 28, wherein said etching further comprises forming said first or second membrane with a curvature.

30. (original) A method of fabricating a pressure sensor comprising:

bonding a first substrate to a second substrate, said second substrate comprising electrical connections;

etching said first substrate to form a first membrane, a second membrane adjacent and spaced from said first membrane and a reference cavity bounded by said first membrane, wherein said first and second membranes are placed in electrical connection with said connections on said second substrate; and

bonding a third substrate to said first substrate to seal a vacuum in said reference cavity.

31. (original) The method of claim 30, further comprising:

etching holes through said first substrate; and

filling said holes with an anchor material, wherein said first membrane is anchored in said first substrate by said anchor material.

32. (original) The method of claim 31, wherein said filling said holes with anchor material comprises filling said holes with polysilicon.

33. (original) The method of claim 30, wherein said substrates are formed of silicon.

34. (original) The method of claim 30, wherein said etching further comprises forming said first or second membrane with a curvature.

35. (original) A method of integrally fabricating a pressure sensor and an atomic resolution storage (ARS) device, said method comprising:

bonding a first substrate to a second substrate, said second substrate comprising electrical connections;

etching said first substrate to form a first membrane, a second membrane adjacent and spaced from said first membrane, a reference cavity bounded by said first membrane, and a

flexture of said ARS device, wherein said first and second membranes are placed in electrical connection with said connections on said second substrate; and

bonding a third substrate to said first substrate to seal a vacuum in said reference cavity and said ARS device, and providing a vacuum cavity for said ARS device.

36. (original) The method of claim 35, further comprising:

etching holes through said first substrate; and

filling said holes with an anchor material, wherein said first membrane is anchored in said first substrate by said anchor material.

37. (original) The method of claim 36, wherein said filling said holes with anchor material comprises filling said holes with polysilicon.

38. (original) The method of claim 35, wherein said substrates are formed of silicon.

39. (original) The method of claim 35, wherein said bonding said third substrate further comprises forming passageways between said first membrane and said ARS device so that said vacuum of said ARS device can be monitored with said pressure sensor that comprises said first membrane.

40. (original) The method of claim 35, wherein said etching further comprises forming said first or second membrane with a curvature.

41. (currently amended) A pressure sensor comprising:

a membrane integrally formed in a substrate by etching said substrate, wherein said ~~first~~ membrane flexes in response to pressure;

a reference cavity covered by said ~~first~~ membrane, said reference cavity containing a vacuum; and

an electrical connection to said ~~first~~ membrane for measuring a piezo-resistivity of said membrane, said piezo-resistivity varying in accordance with the flexing of said ~~first~~ membrane and said pressure.

42. (original) The pressure sensor of claim 41, wherein said membrane and said substrate are made of silicon.

43. (currently amended) The pressure sensor of claim 41, further comprising:

an upper substrate; and

a lower substrate;

wherein [[said]] <u>a</u> substrate from which said membrane is formed is supported between and bonded to said upper and lower substrates.

44. (original) The pressure sensor of claim 43, wherein said electrical connection is patterned on either said upper or lower substrate.

45. (original) The pressure sensor of claim 41, wherein said first membrane has a curvature.

46. (currently amended) A pressure sensor comprising:

a first means for flexing in response to pressure;

a reference cavity covered by said first means, said reference cavity containing a vacuum;

a second means for forming a capacitor with said first means, said capacitor having a capacitance that varies in accordance with the flexing of said first means and said pressure; and

means for measuring said capacitance;

wherein said second means is adjacent to said first means and not <u>exposed to said vacuum</u> within said reference cavity.

47. (original) The pressure sensor of claim 46, wherein said first and second means each comprise a membrane made of silicon.

48. (original) The pressure sensor of claim 46, wherein said means for measuring said capacitance comprise electrical connections patterned on a substrate supporting said first and second means.

49. (original) The pressure sensor of claim 46, wherein either said first or second means has a curvature.

50. (original) A pressure sensor comprising:

a first means for deforming in response to pressure;

a reference cavity covered by said first means, said reference cavity containing a vacuum; and

means for measuring a piezo-resistivity of said first means, said piezo-resistivity varying in accordance with the deformation of said first means and said pressure.

51. (original) The pressure sensor of claim 50, wherein said first means comprise a membrane made of silicon.

52. (original) The pressure sensor of claim 50, wherein said first means has a curvature.

53. (currently amended) A pressure sensor comprising:

a first membrane that flexes in response to pressure;

a reference cavity covered by said first membrane, said reference cavity containing a vacuum; and

a second membrane adjacent to said first membrane, said first and second membranes forming a capacitor having a capacitance that varies in accordance with the flexing of said first membrane and said pressure;

wherein one of said membranes is <u>formed with a curvature</u> ~~curved~~ with respect to the other said membrane.

54. (original) The pressure sensor of claim 53, wherein said first and second membranes are made of silicon.

55. (original) A method of fabricating a pressure sensor comprising:
etching a silicon substrate to form a reference cavity; and
etching said silicon substrate to form a first membrane having a curvature.

56. (original) The method of claim 55, further comprising:
etching said silicon substrate to form a second membrane;
forming a capacitor of said first and second membranes.

57. (new) A pressure sensor comprising:
a first membrane that flexes in response to pressure;
a reference cavity covered by said first membrane, said reference cavity containing a vacuum; and
a second membrane adjacent to said first membrane;
wherein said reference cavity and said second membrane are disposed on opposite sides of said first membrane, said first and second membranes forming a capacitor having a capacitance that varies in accordance with the flexing of said first membrane and said pressure.

58. (new) The pressure sensor of claim 57, wherein said first and second membranes are made of silicon.

59. (new) The pressure sensor of claim 57, further comprising:
an upper substrate; and
a lower substrate;

wherein said first and second membranes are supported between and bonded to said upper and lower substrates.

60. (new) The pressure sensor of claim 59, further comprising electrical connections patterned on one of said substrates and in electrical connection with said first and second membranes for measuring said capacitance.

61. (new) The pressure sensor of claim 57, wherein said first and second membranes are formed in a silicon substrate.

62. (new) The pressure sensor of claim 61, further comprising a polysilicon anchor on both edges of said first membrane securing said first membrane in said silicon substrate.

63. (new) The pressure sensor of claim 57, wherein said first or second membrane is formed with a curvature.

REMARKS

This preliminary amendment is entered as a matter of right prior to examination of the above-identified continuation application. Claims 1-63 are pending for consideration.

Most of the claims presented herein were presented and considered in the parent application. Accordingly, Applicant will now respond to some outstanding issues which were raised as to the foregoing claims in the prosecution of the parent application. Applicant respectfully requests that these comments be taken into consideration and responded to in any Office Action issued on the present application.

With regard to the prior art, the claims 1-5, 41-44, 46-48, 50-52 and 60-66 previously rejected as anticipated under 35 U.S.C. § 102(b) by U.S. Patent No. 4,943,032 to Zdeblick ("Zdeblick"); and claims 1-7 and 41-54 as anticipated under 35 U.S.C. § 102(b) by U.S. Patent No. 5,578,843 to Garabedian et al. ("Garabedian"). These rejections are respectfully traversed for at least the following reasons.

Claims 1 and 46 have been amended herein to more clearly define over the teachings of the Zdeblick and Garaedian references.

Claim 41 recites:

A pressure sensor comprising:

a membrane integrally formed in a substrate by etching said substrate, wherein said membrane flexes in response to pressure;

a reference cavity covered by said membrane, said reference cavity containing a vacuum; and

an electrical connection to said membrane for measuring a piezo-resistivity of said membrane, said piezo-resistivity varying in accordance with the flexing of said membrane and said pressure.

Similarly, claim 50 recites:

A pressure sensor comprising:

a first means for deforming in response to pressure;

a reference cavity covered by said first means, said reference cavity containing a vacuum; and

means for measuring a piezo-resistivity of said first means, said piezo-resistivity varying in accordance with the deformation of said first means and said pressure.

In contrast, neither Zdeblick or Garabedian teach or suggest the claimed pressure sensor in which piezo-resistivity is monitored to determined pressure. In fact, neither Zdeblick or Garabedian even contain the term piezo-resistivity. This point was raised previously, but no official response has been made by the Office.

In previous prosecution, it was alleged that Zdeblick teaches the use of piezo-resistivity to measure pressure at col. 18, lines 52-56 and col. 19, lines 46-55. This is incorrect. Applicant has carefully reviewed these portions of Zdeblick and finds that neither even mentions piezo-resistivity and, clearly, there is no teaching of piezo-resistivity to measure pressure. Col. 18 mentions the formation of a resistive element, but not in connection with a pressure sensor based on piezo-resistivity. Col. 19 appears wholly irrelevant. Applicant requests that it be clearly explain how and where Zdeblick teaches the elements of claims 41 and 50 or that this rejection be reconsidered and withdrawn.

Garabedian is no better. With regard to claim 41, the Office Action cites col. 7, lines 49-62 of Garabedian. This section of Garabedian has been quoted above and discusses the formation of a capacitor, *not a resistor*. Nowhere does Garabedian teach or even remotely suggest the use of piezo-resistivity to monitor pressure as recited in claims 41 and 50.

In conclusion, previous prosecution has completely failed to explain how or where the cited prior art teaches the elements of claims 41 and 50 that use piezo-resistivity to measure

pressure. Moreover, Applicant has carefully reviewed the cited references and finds no suggestion of the subject matter of claims 41 and 50.

"A claim is anticipated [under 35 U.S.C. § 102] only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference." Verdegaal Bros. v. Union Oil Co. of California, 2 U.S.P.Q.2d 1051, 1053 (Fed. Cir. 1987) (emphasis added). See M.P.E.P. § 2131. Consequently, the rejections based on Zdeblick and Garabedian of claims 41-45 and 50-52 should be reconsidered and withdrawn.

Claim 57 recites:

> A pressure sensor comprising:
>
> a first membrane that flexes in response to pressure;
>
> a reference cavity covered by said first membrane, said reference cavity containing a vacuum; and
>
> a second membrane adjacent to said first membrane;
>
> wherein said reference cavity and said second membrane are disposed on opposite sides of said first membrane, said first and second membranes forming a capacitor having a capacitance that varies in accordance with the flexing of said first membrane and said pressure.

In contrast, however, Zdeblick fails to teach or suggest the features of claim 60. Zdeblick teaches a capacitor formed of two conductive films (668 and 666) ("capacitor plates 666 and 668," Zdeblick, col. 41, line 8). The lower film (666) is disposed on a flexible membrane (674). The conductive films (668, 666) are separated by an evacuated cavity (664).

Zdeblick does not teach or suggest that the "reference cavity and said second membrane are disposed on opposite sides of said [flexible] first membrane," as claimed. Rather, the reference cavity (664) and the other half of the capacitor ("membrane" 668) are both on the same side of the flexible membrane (666, 674).

Again, "[a] claim is anticipated [under 35 U.S.C. § 102] only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference." Verdegaal Bros. v. Union Oil Co. of California, 2 U.S.P.Q.2d 1051,

1053 (Fed. Cir. 1987) (emphasis added). See M.P.E.P. § 2131. Consequently, the rejection based on Zdeblick of claim 57 and its dependent claims should be reconsidered and withdrawn.

For the foregoing reasons, the present application is thought to be clearly in condition for allowance. Accordingly, favorable reconsideration of the application in light of these remarks is courteously solicited. If the Examiner has any comments or suggestions which could place this application in even better form, the Examiner is requested to telephone the undersigned attorney at the number listed below.

Respectfully submitted,

DATE: 18 September 2003

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PLEASE STAMP TO ACKNOWLEDGE RECEIPT OF THE FOLLOWING.

In re Utility Patent Application of: Chien-Hua Chen

Serial No.: Unassigned **Group Art Unit:** Unassigned

Filed: September 18, 2003 **Examiner:** Unassigned

Title: "A Pressure Sensor and Method of Making the Same"

Papers filed:

1. Request for Continuing Application under 37 CFR 1.53(b) (2 pages)
2. Duplicate Copy of Request for Continuing Application under 37 CFR 1.53(b) (2 pages)
3. Continuation Patent Application (23 pages)
4. Drawings (10 pages)
5. Preliminary Amendment (19 pages)
6. Declaration/Power of Attorney (1 page)

Attorney Docket No.: 10011999-5 54 **Attorney:** Steven L. Nichols

All papers filed were sent on September 18, 2003, 2003 via Express Mail, label no.: EV275392031US.